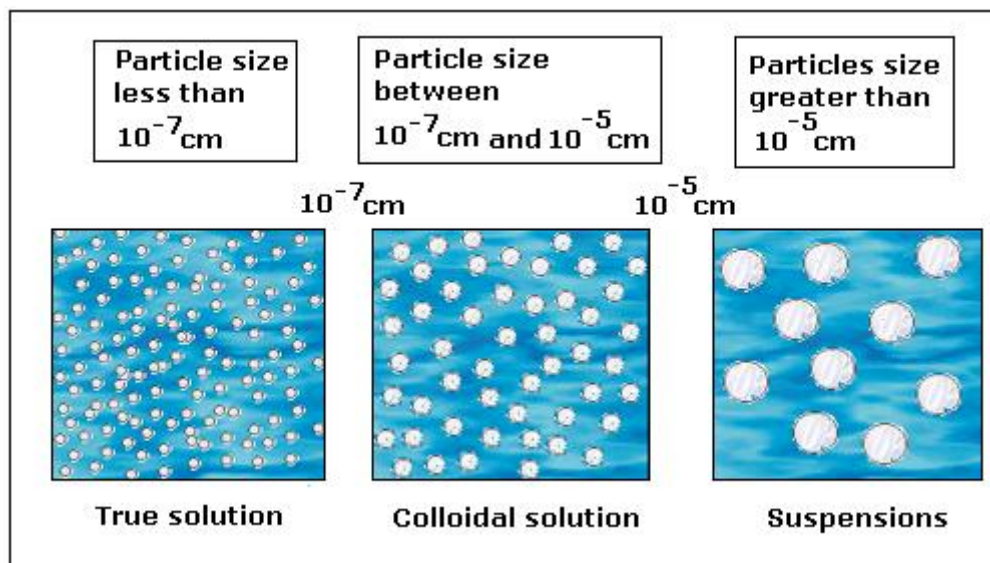


Here's why

A lot of chemical processes take place while the reactants are in solution, usually a water solution.

Mixtures

- Mixtures are _____
- mixtures can be separated into their components _____
- Mixtures come in the form of solutions, suspensions, or colloids.



Suspensions

- Suspensions _____
- Example: _____

Colloids

- Colloids are substances where _____
- Example: _____

Solutions

- Solutions are _____
- Example: _____ Comparison chart solution, suspensions & colloids & solutions

	Solutions	Colloids	suspensions
Type mixture	Homogenous	Heterogeneous	heterogeneous
Particle size	0.1nm-1nm	1-1000nm	>1000 nm
Particles settle out	NO	NO	YES
Can be separated by filtering	NO	NO	YES
Scatter light	NO	YES	May

Other mixtures

- An **aerosol** is a _____
Examples: _____
- An **emulsion** is a mixture of _____ (not mixable).
Examples: _____

- Emulsions are_____. Although the terms *colloid* and *emulsion* are sometimes used interchangeably.

– Examples:_____

- A **foam** is a substance that is _____

- Examples: _____

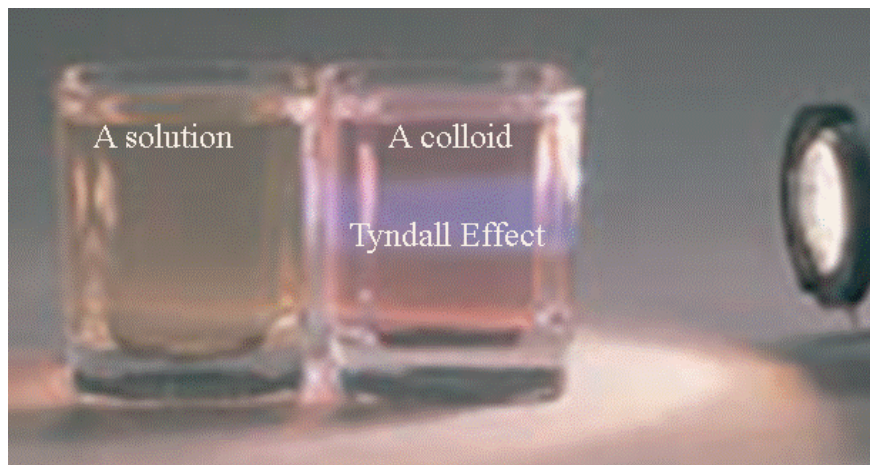
- In most foam, the volume of gas is large, with thin films of liquid or solid separating the regions of gas.

Testing for true solutions

- In true solutions, the solute will not come out of solution without a change in _____or_____
- The Tyndall effect is used to tell the difference between the different types of mixtures: solution, colloid, and suspension.
- For example, the Tyndall effect is noticeable when car headlamps are used in fog (or snow).

Tyndall Effect

- Tyndall scattering occurs when the dimensions of the particles that are causing the scattering are larger than the wavelength of the light that is scattered.
- It is caused by reflection of the incident light from the surfaces of the particles.
- This is also the reason why the sky looks blue: the light from the sun is scattered and we see the blue light because it scatters better.
- The blue light is reflected down to the earth's surface which makes the sky appear blue.



The parts of a solution

- all solutions have two basic parts.
- They are:
 - 1. Solute which is the _____
 - 2. Solvent which is the _____
 - 3. The substance in greatest percentage is usually considered to be the _____

Nine combinations of solvents & solutes

Solvent	Solute	Example
Gas	Gas	Air
Liquid	Gas	Soda
Solid	Gas	Hydrogen on Pt
Gas	Liquid	Water vapor in air
Liquid	Liquid	antifreeze in water
Solid	Liquid	Cu in Hg
Gas	Solid	C in air (soot)
Liquid	Solid	Sugar in water
Solid	Solid	pewter

Solvents & Solutes

- The ability of a solute to mix with a solvent is called_____.
- Some solutes are only slightly soluble in a given solvent
- Some solutes are very soluble in a given solvent.
- This appears to depend on the _____.

"Like dissolves like"

- A General rule applied to solute-solvent relationships goes like this: " Like dissolves like"
- There are two types of solutes and solvents.
 - They are polar and nonpolar.
- SO _____ solutes will dissolve in _____ solvents
- And _____ solute will dissolve in _____ solvents.

And there are some substances that can be both polar and nonpolar because of molecular structure

- Solvents can be selective about what solutes they will dissolve due to electronic structure.

Solutes, Solvents & Conditions

- Generally three things affect the solubility of a solute in a solvent.
 - They are:
 - . _____
 - . _____
 - . _____

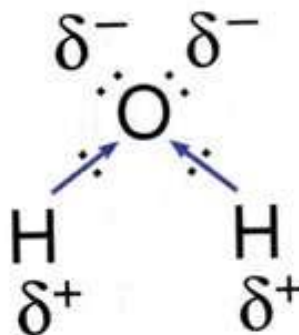
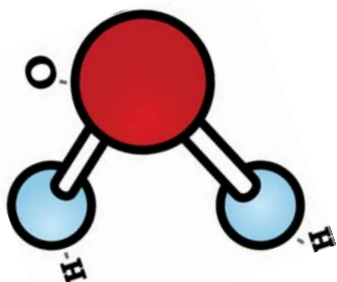
Some solutes such as gases will respond to _____ & _____

Solid solutes will not be affected by _____ but are very sensitive to _____

Solvent molecular structure

- Water is a _____.
- Water is the _____
- Water is polar because of the _____
- This occurs because oxygen does _____

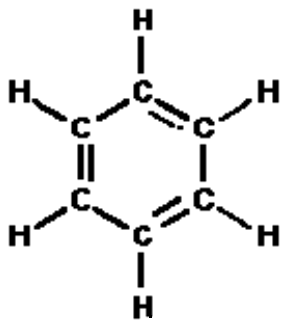
- The electrons from the hydrogen atoms spend most of the time close to the _____
- This creates a _____ charge (pole) on the oxygen atom and a _____ charge (pole) on each of the hydrogen atoms.



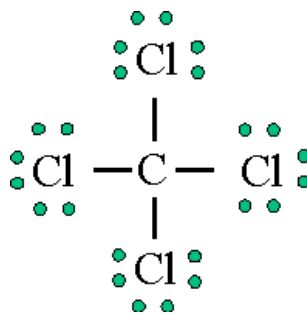
Nonpolar solvents

- Some organic substances such as carbon tetrachloride and benzene are nonpolar solvents.

The nonpolar solvent benzene



Carbon tetrachloride

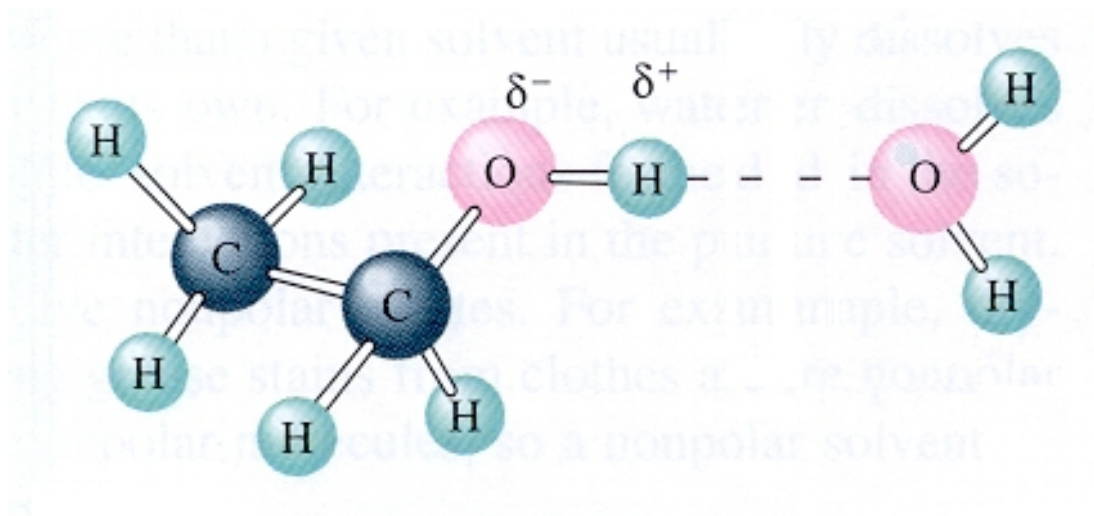


- This is due to an _____
- Therefore they will dissolve _____ solutes and will not dissolve _____ compounds.

Solvents that is both polar & nonpolar

- Alcohols such as methanol, ethanol, and glycols (antifreeze) are both polar and nonpolar.

- The functional group of the alcohols is_____.
- The electronegativity of oxygen is substantially greater than that of carbon and hydrogen.
- The covalent bonds of this functional group are polarized so that oxygen is electron rich.



Solutes & Solvents Summary

- Generally **polar solute** molecules will **dissolve** in **polar solvents**
- **Non-polar solute** molecules will **dissolve** in **non-polar solvents**.

Solutes & Solvents

- The polar solute molecules have a _____end on the molecule.
- If the solvent molecule is also_____, it will have a positive and negative end.
- The opposite ends of the 2 types of molecules will attract. (plus to minus and minus to plus)

- This is a type of intermolecular force known as_____
- All molecules have a type of intermolecular force much weaker than the other forces called_____.
- This gives the non-polar solvents a chance to solvate the solute molecules.

Le Chateliers Principle applied to solutions

- Most solutions will achieve an equilibrium _____

- However, when a stress occurs the equilibrium will find a new set of conditions.
- Stresses that can be applied to a solution:
 - ._____
 - ._____
 - ._____
 - ._____
- The solution will make adjustments to the change in conditions.

Equilibrium & saturation

- Saturation is _____

- If the conditions are stable (not changing) then the _____

- The conditions are said to be at_____
- Saturation at equilibrium is _____meaning that the saturation point will change if the conditions change.
- It means that same amounts of solute will move in and out of solution.

- If the system is at equilibrium then equal amounts of solute will dissolve and recrystallize at the same time.

Equilibrium & Saturation & Change

- Depending on the direction of the change in the equilibrium two things can happen.

- First some of the solute may come out of solution

- . _____

- . _____

- Second the equilibrium may move in a direction to _____

Solubility redefined

- Therefore we must adjust the definition of solubility to include conditions.

- Solubility is _____

Saturated and unsaturated defined

- At a given set of conditions:

a solution that can hold the maximum amount of solute is said to be ***saturated***.

a solution that does not have the maximum amount of solute is said to be ***unsaturated***.

The effect of pressure on solutions

1. Pressure has _____ effect on **liquid/liquid** solutions.
2. Pressure has _____ effect on **solid/liquid** solutions.
3. Pressure has _____ effect on **gas/liquid** solutions.

Gases in Solution

- As the pressure on the gas over the solution _____; the concentration of the gas in the solution _____.
- This system follows two laws.
 - Le Chateliers Principle
 - Henry's Law which states that the solubility of a gas in a liquid is directly proportional to the pressure of the gas above the liquid.
- _____ the pressure of a gas over a liquid and more gas will dissolve in the liquid
- This will *increase* the _____ of the gas in the solution.
- _____ the pressure of the gas over the liquid and some of the gas will come out of solution.
- This will _____ the concentration of the gas in the solution.

Why did my soda explode?

- If the pressure is quickly released, the gas will rapidly come of solution.
- The rapid release of a gas from a gas/liquid solution is called _____
- Best example: _____

Gas/gas solutions & Dalton's Law of Partial Pressure

- If you have a mixture of gases as the solute in a gas/ liquid solution, the solubility of each gas solute is _____.
- Or each gas dissolves to the same extent that it would if the other gases were not there.

The effect of temperature on solutions

- Some general things about solubility and temperature.
 - The solubility of a gas _____ as the temperature of the solvent increases.
 - Temperature has _____ affect on liquid/liquid solutions.
 - Generally, increasing the temperature _____ the solubility of solids in liquids.
 - Another way to say this is increasing temperature increases _____

What three conditions affect the solubility of a solid in a liquid?

- They are:
 - _____
 - _____
 - _____
- Temperature has the _____ effect on solids in liquid systems.
 - When temperature is _____ the dissolving process increases.
 - This happens because there is **more kinetic energy in all if the particles involved and attractive forces are more easily overcome.**

3 ways help to increase the rate at which a solid will dissolve in a liquid

- 1. _____
- 2. _____
- 3. _____

Why do these three methods work?

- 1. _____
- 2. _____
- 3. _____

The mechanics of dissolving a solid in a liquid (water)

- Three actions occur:
 - 1. Solute particles are separated (endothermic process)
 - 2. Solvent particles are moved apart to make room for the solute particles (endothermic process)
 - 3. Solute particles are attracted to the solvent particles (exothermic process)

Energy involved in the dissolving process

- 1. separating solute particles requires energy (endothermic process)
- 2. moving solvent particles apart to make room for the solute particles requires energy
(Endothermic process)
- 3. Solute particles attracted to the solvent particles releases energy
(Exothermic process)

What happens doing energy changes in the dissolving process?

- Net change is _____, **temperature decreases** as solid dissolves and **solubility increases as temperature increases**.
- If net change is _____, **temperature increases** as solid dissolves and **solubility decreases with increasing temperature**

Entropy and dissolving related

- Back to the entropy and lower energy state thing.
- Natural processes tend to go toward a lower energy state.
- If a dissolving process is endothermic; it is because the entropy of the system increases.

- Dissolving a gas into a liquid produces a decrease in entropy and is also exothermic.
- **So, solubility should decrease with increasing temperature and does.**

Heat of solution

- The heat of solution is _____

- is measured in kilojoules per mole of solute dissolved in a specific number of moles of solvent,
- If **dissolving is endothermic**, the heat of solution is _____
- If **dissolving is exothermic**, the heat of solution is _____

Some other things going on in solutions

- Solvation is the process by which particles of the solvent pull particles of solute away from the solute crystal.
- Hydration occurs when molecules of water surround particles of solute in solution.

The terms miscible & immiscible

- They apply to liquid/liquid solutions
 - Miscible means the two liquids will _____
 - example: _____
 - Immiscible means the two liquids will _____
 - example: _____

Concentration

- Concentration is _____
- These are qualitative terms and are relative (subject to personal interpretation).
 - **Concentrated** means a _____ amount of solute in the solution
 - **Dilute** means there is a _____ amount of solute in the solution.
- _____ uses numbers to express the amount of solute in a given amount of solution or solvent.

Three main quantitative terms for concentration

- three main terms used are
 - percent by weight,
 - moles per liter of solution (molarity)
 - moles per kilogram of solvent (molality).

Supersaturation defined

- Supersaturation is defined as a condition where an excess amount of solute remains in solution at a lower temperature.
 - This condition is unstable.
 - It is so unstable that even a slight tap on the container or addition of a small crystal will cause the excess solute to precipitate out of solution.

Colligative properties

- Colligative properties depend only on _____

- Non-colligative properties depend on the identity of the dissolved species and the solvent.

Four colligative properties

- There are four:
 - Vapor pressure changes
 - Freezing point depression of the solvent
 - Boiling point elevation of the solvent
 - Osmotic pressure

Why do these properties change?

- The reason for the change is because _____

 - Example: freezing particles of solvent _____

Vapor pressure change

- As solute is added to a solvent, the vapor pressure over the liquid will increase which will increase the boiling point.
- The math relation looks like this:

$$\Delta P_{\text{vapor}} \propto m$$

Where ΔP_{vapor} is the vapor pressure and m is molal concentration.

Freezing point depression

- As solute is dissolved into a solvent, the freezing point of the solvent is _____
- Mathematically, the amount the freezing point (temperature) is lowered is directly proportional to the molal concentration.
- There are 3 variables needed to calculate fp depression. They are :
 1. ΔT_f m where ΔT is change in temperature
 2. m is molal concentration.

3. K_f is called the freezing point constant: it is the amt of change the fp will undergo for a 1 molal solution. Fp will go down.

$$\Delta T_f = (m)(K_f)(\# \text{ particles})$$

Boiling point elevation

- When a solute is dissolved into a solvent, the boiling point of the solvent is

- This depends on the amount of solute dissolved into the solvent.
- the amount the boiling point (temperature) increases is directly proportional to the molal concentration.
- The math looks like this:
 - $\Delta T \propto m$
 - Where ΔT is change in temperature and m is molal concentration.
 - K_b is called the boiling point constant: it is the amount of change (raising) the boiling temperature will undergo for a 1 molal solution.

$$\Delta T_{bp} = (m)(K_b)(\# \text{ particles})$$

Classifying Solutions

- If the solution:
 - Can conduct electricity.
 - Cannot conduct electricity.
- If the solute will:
 - Produce ions in water solution.
 - Break into molecules in water solution.

Electrolytes & nonelectrolytes

- Substances that can dissolve in water and the solution can conduct electricity are called _____
- Substances that can dissolve in water and the solution cannot conduct electricity are called _____

Electrolytes in water solutions

- These compounds will produce ions in water solutions.

These solutions are called _____ solutions

Formation of ions

- Theory of ionization
 - Faraday – electricity made the ions from the solute in the solution.
 - Arrhenius – ions produced by the “ionization” of the particles of the solute.
 - Complete ionization will occur in dilute solutions
 - Dynamic equilibrium will occur in concentrated solutions (ions go back and forth between solution and molecules)

Ionic compounds dissolving

- Polarity of water very important
- Dipoles on water molecule attract the ions in the crystal.
- This brings the ions into the solution.
- Energy is released in the process (exothermic)
- Solution processes with water as the solvent is called hydration. This occurs when the ions are surrounded by water molecules.

Evaporation of the solvent

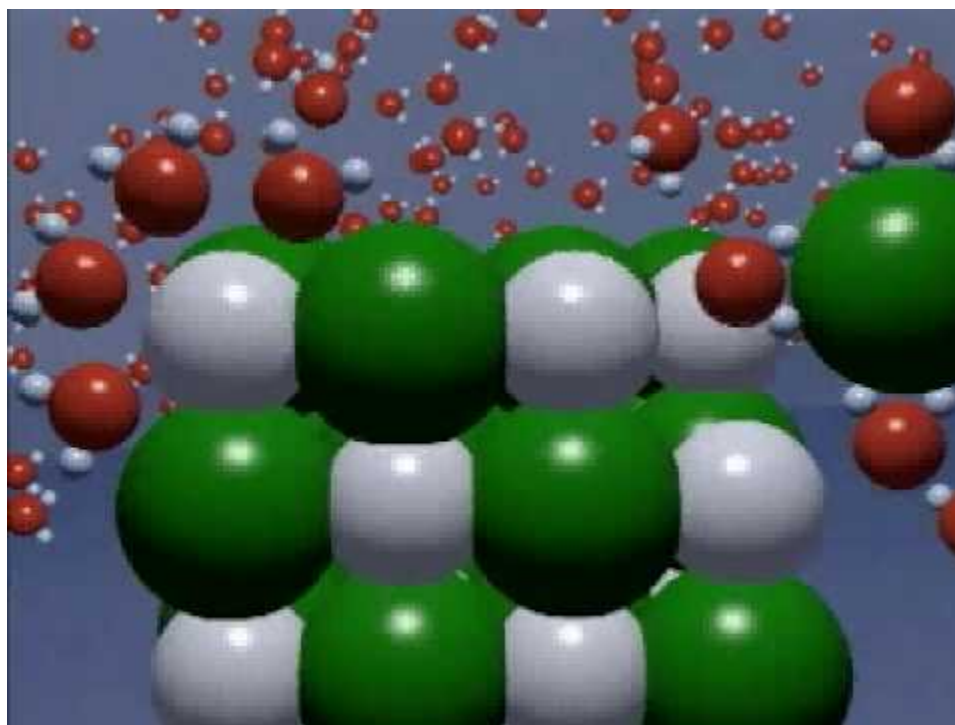
When the water evaporates, the reverse process occurs. The ions will go back together to rebuild the crystals.

Role of energy play in the dissolving process

- The energy released when ions become surrounded by water molecules is called the *heat of hydration*.
- More energy is released when small ions are hydrated then when large ions are hydrated.
- The energy released or absorbed depends on the relative amounts of energy needed
 - 1. _____
 - 2. _____

What is dissociation?

- **Dissociation** is the _____



Solubility & dissociation related

- How well an ionic compound dissociates in water is how soluble it is
- Ionic compounds have different degrees of solubility from very soluble to very slightly soluble.
- Even those ionic compounds that are "*insoluble*" will dissociate to some degree.

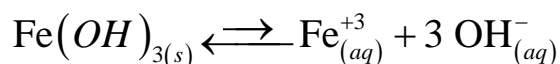
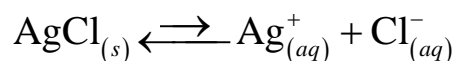
Slightly soluble ionic compounds

- in water:

Equilibrium will occur between the ions and the crystal

The solution will be saturated (has maximum amount of solute at a given temperature)

- two slightly soluble ionic compounds in water; would look like this:



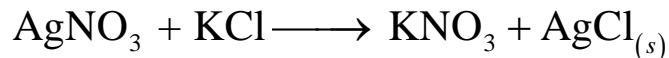
Precipitation reactions

- When two solutions of highly soluble compounds are mixed together ; they may produce a slightly soluble compound.
- This is really a double replacement reaction.
- The majority of the slightly soluble compound will ***precipitate*** or come out of solution and settle on the bottom of the container.
- The ions of the remaining compound will stay in solution as **spectator ions**.

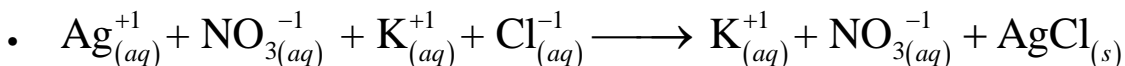
Ionic equations

- Ionic equations show the ions of the compounds in aqueous solutions.
- The ***complete ionic equation*** shows ***ALL*** of the ***ions*** produced by compounds and the slightly soluble compound.
- The net ionic equations shows those ions(on the left) that make up the slightly soluble compound(on the right).

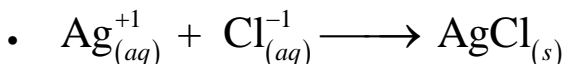
- The double replacement version:



- The complete ionic equation:



- The net ionic equation will look like this:



Spectator ions

- The ions that do not make up the precipitate and remain in the solution are called *spectator ions*.

Some molecular compounds conduct electricity in water

- So far in our discussion, all of the compounds have been ionic. BUT there are some molecular compounds that will conduct electricity in water solutions.

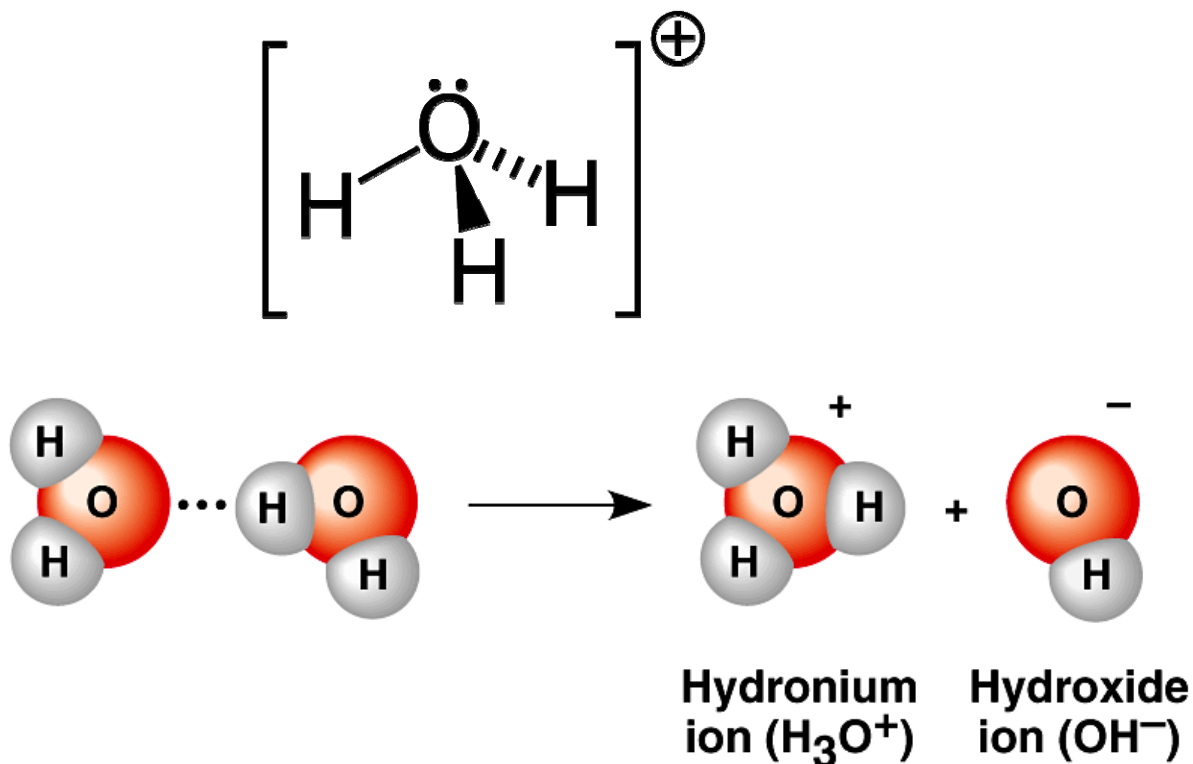
Solution process for molecular electrolytes

- When a molecule containing polar bonds is dissolved in water, the dipoles of the water attach to the charged areas of the polar molecules.
- For nonelectrolytes, the complete molecule goes into solution.
- For electrolytes, the weak _____ bonds are broken in the molecule; forming ions.
- Examples of these compounds are: _____

Formation of hydronium ions

- When hydrogen ions are formed in a solution a special type of ion forms.
 - Hydrogen ions are just a proton because the electron has been removed or stayed with the more electronegative atom.
 - Hydronium ions are hydrated hydrogen ions.
 - A hydrogen ion with one _____.

The ion is written this way: H_3O^+



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Strong and weak electrolytes

- A strong electrolyte is a substance that will completely ionization(come apart 100%) in dilute solution.
 - Examples: HCl and any soluble compound can exist as ions when dissolved
- A weak electrolyte is a substance that produces a low number of ions in solution.
 - Example: HF(because HF is in solution as more molecules than ions)

Some properties of electrolyte solutions

Conductivity of solutions

- These solutions will conduct electricity.
- They will also depress the fp and elevate the bp of the solvents

Freezing point affected in electrolytes solutions

- Freezing point depression has been observed in solutions produced by electrolytes in water. BUT.....
 - Electrolytes in water appear to amplify this effect.
 - Example: _____
 - A 1 molal solution of sugar will lower the fp of a water solution to -1.86°C .
 - A 1 molal solution will lower the fp of a water solution to approximately -3.72°C .

What is apparent degree of ionization?

- If we carefully calculate the fp of a 1 *m* solution of NaCl we find that -3.72°C only works at low molal concentrations.
- But at higher concentrations the fp is higher than the predicted -3.72°C .
- So does this solute really come apart 100%?

Two things affect the apparent degree of ionization

- It appears that the number of particles (ions) and their ability to move in a solution has a lot to do with the changes in fb & bp of a solvent (in this case water).
 1. The attractive forces between the ions and the molecules have a greater effect.
 2. A number of water molecules will cluster around an ion. The number of water molecules involved depends on the charge and size of the ion.

So, the apparent degree of ionization depends on...

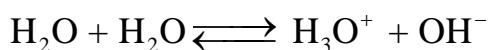
- The size of these ion-water clusters causes the changes.
- As with any system, equilibrium will be established. Some ions will go into solution and some will return to the solid crystal.
- The degree that this occurs is called the Apparent degree of ionization.

Water as an electrolyte

- It appears that water is a very weak electrolyte. This means that water spends most of its time as molecules.
- A few water molecules will ionize to form hydronium ions and hydroxide
 - 2 molecules in 1 billion will ionize

The ionization of water

- The equations to show this looks like this:



So absolutely pure water will not conduct electricity. BUT tap water will and electricity and tap water can be quite dangerous. Why?

Remember water is the universal solvent and will dissolve stuff where ever it travels!!!!

The Debye-Hückel Theory

- The ions of solute are clustered together with ions of opposite charge.
- These clusters can act like individual particles.
- This reduces the total number of particles in the solution thus reducing the predicted effects of the ions on freezing point & boiling point.

